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HEAD, CANE, AND CORDON PRUNING OF VINES

BY

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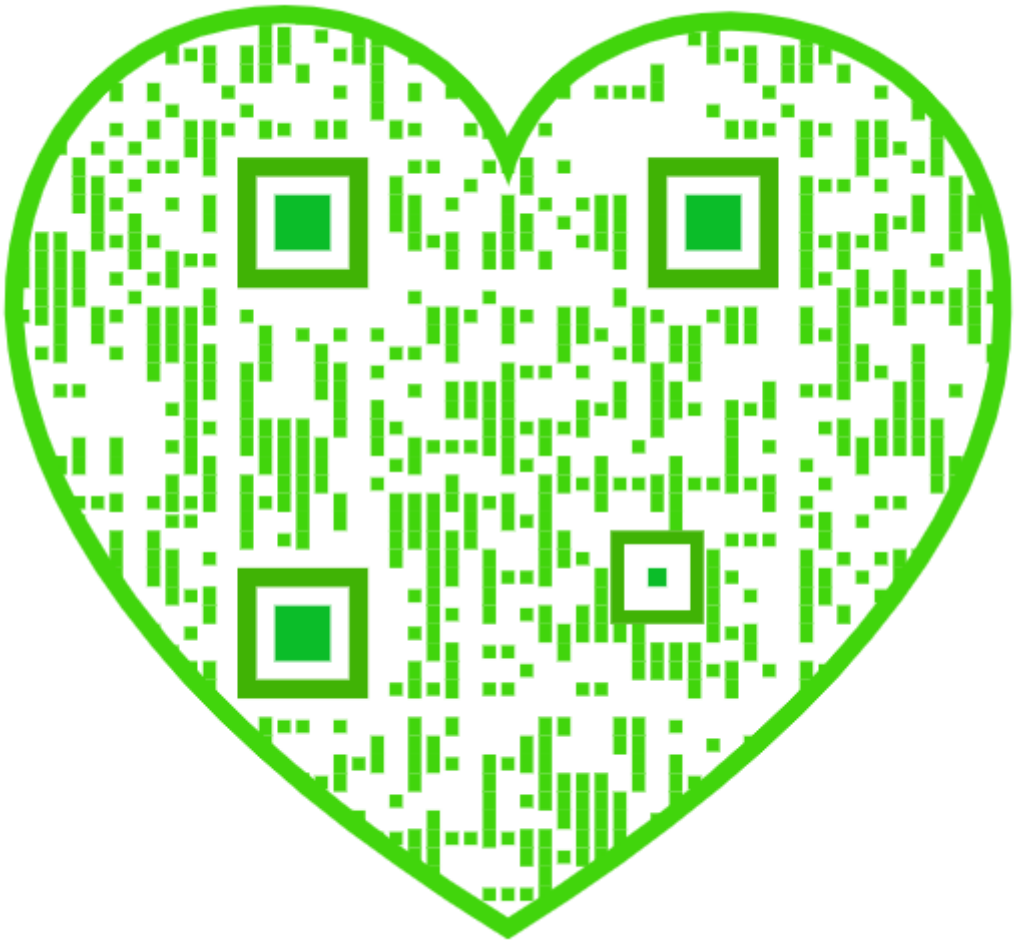
The various methods of pruning vines used successfully in California may be grouped into three general types for which *head, cane* and *cordon* are convenient titles. There are various sub-types under each of these general types, each of which has advantages for special conditions. The types and sub-types described in this circular are those which seem most generally adapted to the conditions of grape growing in California.

HEAD PRUNING

The most usual form given to the vine, where the Vinifera or European grape is grown, is that of a small upright shrub (fig. 1). The mature vine consists of a vertical stem or *trunk* bearing at its summit a ring of *arms* or short branches ascending in the form of a *vase* or hollow inverted cone. At the end of these arms, at each winter pruning, are left the *spurs* which consist of the basal portions of *canes* which are the matured *shoots* which grew during the previous summer. The point or region at which the trunk divides into or bears the arms is called the *head.*

This method of training is often spoken of as vase or goblet pruning, but the vase-formed arrangement of the arms, though usual, is not universal nor essential, and the term *head pruning* seems preferable.

The essential points to be kept in mind in developing a vine of this form are:



THE TRUNK

1. The trunk should be vertical. This is necessary to permit of close plowing and cultivation without injury to the vine; to facilitate hoeing and the removal of *suckers* (shoots from below ground) and of *water sprouts* (shoots from the old wood). It is useful also in the application of various sprayings and treatments needed to control mildew, vine-hoppers and other pests and diseases.

2. It should be smooth, straight and without large wounds. This insures the health and long life of the vine by protecting its most vital part from boring insects, decay fungi and black-knot.

Fig. 1.—Head pruned vines with high, medium and low heads.

3. It should be sufficiently high to keep the fruit from touching the ground and, in frosty locations, to give the young shoots some protection against spring frosts. The larger and more vigorous the vine, the higher the trunk should be, especially with table grapes. (See fig. 1.)

4. To keep the trunk strong and healthy, suckers should not be allowed to develop. If removed carefully in the spring and early summer during the first three or four years they will cease to form and much troublesome work will be saved in future years.

If allowed to grow all summer or imperfectly removed, they will cause the formation of burls on the trunk near and below the surface of the ground. These *sucker burls* will continue to produce an increasing crop of suckers every year. If these suckers are not removed they will take the upward sap stream from the roots and the top of the vine will finally be starved or killed.

THE HEAD

1. The head should be definite—that is, the arms should start as nearly as possible from the same level, the top of the trunk. This is to give the even distribution of the arms necessary to insure equal exposure of the fruit to sun and air and consequent equal development of color, sugar and flavor.

2. This definite head is a matter of gradual development and is to be obtained only after several years of well-planned training. It is seldom complete until the vine is 6 or 7 years old. An attempt to hasten it will defeat its own object and result in loss of crop and in a misshapen vine.

THE ARMS

1. The number of arms should be sufficient to furnish the spurs necessary for the number of bunches the vine is capable of maturing. This will vary according to the size, vigor and variety of the vine. It may be only three or four, each with a single spur, on a small vine of a weak variety, closely planted in a soil of moderate fertility. It may, on the other hand, be six or seven, dividing into two or three at their extremities, on a large vine of a vigorous variety with abundant room in a rich soil. In the one case six to eight fruit buds would be left, in the other thirty to forty.

2. The length of the arms will vary in the same way and with the same factors. The point to be kept in mind is that they should be sufficiently long to allow the bunches room to develop without crowding or interlocking. This is especially important with table grapes. This length will vary from five or six inches with very small vines to eighteen or twenty with very large.

3. The arms originate from spurs and increase in length by the addition each year of a part of the spur of the previous year. They require several years therefore to reach their full length and the elongation can be controlled and adjusted by appropriate pruning to keep pace with the development of the vine and the increase of crop. Finally when the vine reaches the stage of full bearing, some or all of the arms will have reached the length which is judged best in the particular case. Unless prevented, however, the arms will continue to

elongate and finally will become too long and weak to support the crop and will be in danger of injury in cultivation.

4. Before this stage is reached, measures must be taken to avoid the difficulty. This is done by leaving a short spur (*replacing spur*) suitably placed on the arm, well below its extremity. This spur will give rise to a cane, which can, the next year, be used as a spur to supply fruit and also to serve as the start of a new arm. The elongated part of the old arm beyond this spur is then removed, leaving in its place the new short arm.

By this device applied whenever necessary the undue elongation and weakening of arms can be avoided. The lower one-third or so of the arm should be considered a permanent part of the vine in the same way and for the same reasons as the trunk. The renewal of arms therefore should not extend too far down.

THE SPURS

1. Each year the dormant vine is pruned and all the canes produced during the last growing season are removed entirely except a few which are shortened to one, two or three or rarely more buds. What is left of these shortened canes constitute the spurs. All the fruit and most of the growth of the following year comes from the buds of these spurs.

2. To preserve, to improve and to develop the form of the vine, it is necessary to make a wise selection of canes for spurs.

3. In varieties suited to head pruning, any of the buds on the spurs may be fruitful. Often the base bud is sterile and the first bud less fruitful than the second. From the second up, the buds are usually equally fruitful where they are well formed and mature. It is possible, therefore, to control the crop within limits, by the number of spurs and the number of buds left at the winter pruning.

4. A vine of a given size and vigor is capable of producing a certain crop of good grapes. If we leave more fruit buds than are necessary for this crop the number of grapes and of bunches will be increased up to a certain point but the quality will be decreased. If we carry this generosity far enough the grapes may fail to develop or ripen and the vine will be weakened or even killed by bearing a large crop of worthless fruit. If we leave fewer buds than are needed for the best results we will increase the size and quality of the fruit up to a certain point but with loss in quantity. Beyond this point the crop is diminished without any gain in quality but the vine is invigorated by its failure to bear much crop.

5. The most important problem of the pruner, therefore, is to decide how many buds to leave. He must decide how many spurs to

leave on each vine and on each arm and how many buds to leave on each spur. Certain general rules can be given but these can be applied successfully only by the careful observing pruner with experience or expert direction.

6. The more well nourished and matured growth that has been made during the current season, that is, the more vigorous the vine, the more good grapes it is capable of producing during the coming year.

This rule applies also to parts of vines—to each arm and to each spur.

7. The most useful general rule for a pruner, is, first, to note whether the vine shows unusual vigor, medium vigor, or signs of weakness. If the first, more fruit buds should be left than was done the previous year; if the last, fewer should be left. If the vine seems of medium or normal vigor about the same number of buds should be left as were left at the preceding pruning. This rule applies not only to the whole vine but to individual arms and spurs and is independent of the causes of the degree of vigor. It is, therefore, a better guide to the pruner than a knowledge of what the vine produced the previous year.

THE ROOTS

1. The root system consists of the *main roots* which originate on the underground stem and, passing downwards, divide into the *branch roots* which in turn gives rise to the *fibrous* or *feeding roots.*

The main and branch roots are permanent and serve to conduct the complementary food streams—the water and soil nutrients from the feeding roots and the starch and sugar from the leaves. New feeding roots are produced continuously whenever the moisture and temperature conditions are favorable. They function as feeders for a short time and then die or become part of the conducting system.

2. It is important that the main roots be protected from injury. This is possible only if they lie below the depth to which the implements of tillage penetrate which, close to the vine, is about four or five inches. Roots above this level are called *surface roots.*

3. If surface roots are allowed to remain on young vines during the first two or three years they develop into main roots and the deeper roots may develop little or not at all.

A vine in this condition may grow as well or better than a vine with only deep main roots but is in a perilous position. At any time a plow may strike the surface main roots, cut them off and so destroy the whole root system below and make large, jagged wounds in the trunk.

4. This danger can be avoided by removing all the surface roots during the first two or three years at the winter pruning. In this way they are prevented from developing into main roots and in the meanwhile a system of main roots is developed at lower and safer levels.

Fig. 2.—Pruning at planting. Nursery rooting before and after pruning.

After the third year, the vine may be considered safe in this respect. Any surface roots produced after this perform their function of feeding roots and seldom grow large, as they cannot compete with the large main roots already established lower down. If these small surface roots are caught by the plow little damage is done as they constitute a very small part of the rooting system and the plow removes them without making wounds in the main roots or the underground part of the trunk.

DEVELOPMENT OF THE VINE

1. *Pruning at planting.*—When a rooted or grafted vine is planted, the roots should be shortened to from two to four inches and all the new growth of top removed except one cane which should be shortened to two buds. (Fig. 2.)

When planted, only these buds should show above the surface of the ground. As a rule no summer pruning should be done and staking is unnecessary. The only exceptions to this are in some regions where the heat, soil and water conditions are so favorable to quick development, that the work of two seasons can be done in one. The treatment

Fig. 3.—First winter pruning. *a.* Pruning the top. *b.* Removal of suckers and surface roots.

in these cases during the first year is identical with the treatment for the second year described here for more usual conditions.

2. *First winter pruning.*—At the end of the first growing season, the young vine should have made a growth above ground of one or more canes from one to three feet long and a strong widely spreading root system.

The tops are pruned in winter after the leaves have fallen. Only one cane is reserved and this cut back to two buds. (See fig. 3.)

The vine after pruning, therefore, looks above the ground almost as it did when planted the previous spring. Its condition, however, is very different. It is now supplied with a complete root system and is prepared to make a very much larger growth during the coming season.

Its work during the second season is to produce a single strong cane from which a trunk can be developed. To do this, it requires not

only cultivation and irrigation but support and training during the spring and summer.

As soon as possible after pruning, the vineyard should be staked with 3-, 4- or 6-foot stakes according to the height it is desired to raise the head. (See fig. 1.)

Well before the vines start to bud in the spring, a single furrow should be thrown away from each side of each row of vines and the

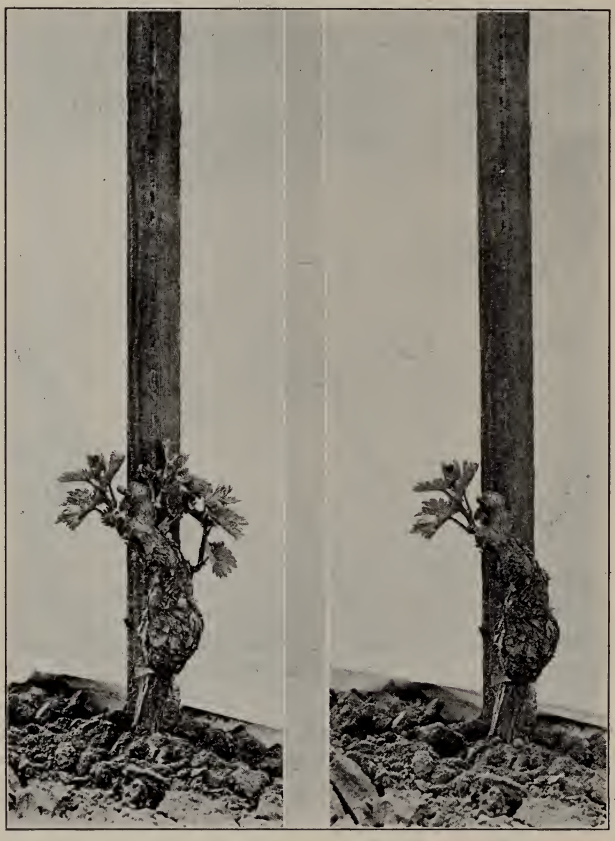


Fig. 4.—Second spring treatment—first disbudding.

ridge hoed away for six inches on each side of the vine. This will expose suckers and surface roots and allow them to be removed completely with a sharp pair of pruning shears without leaving stubs to produce more suckers and surface roots the following years. (See fig. 3*b*.) If this is neglected or improperly done it will be the cause of much trouble and expense later. Vines properly suckered and surface-rooted during the first two years give no trouble in this respect later.

3. *Second summer treatment.*—In spring, as soon as a large proportion of the vines have produced a shoot two to four inches long, they should receive the first disbudding. This consists of rubbing off every shoot or swollen bud but the one which has grown the most. (See fig. 4.)

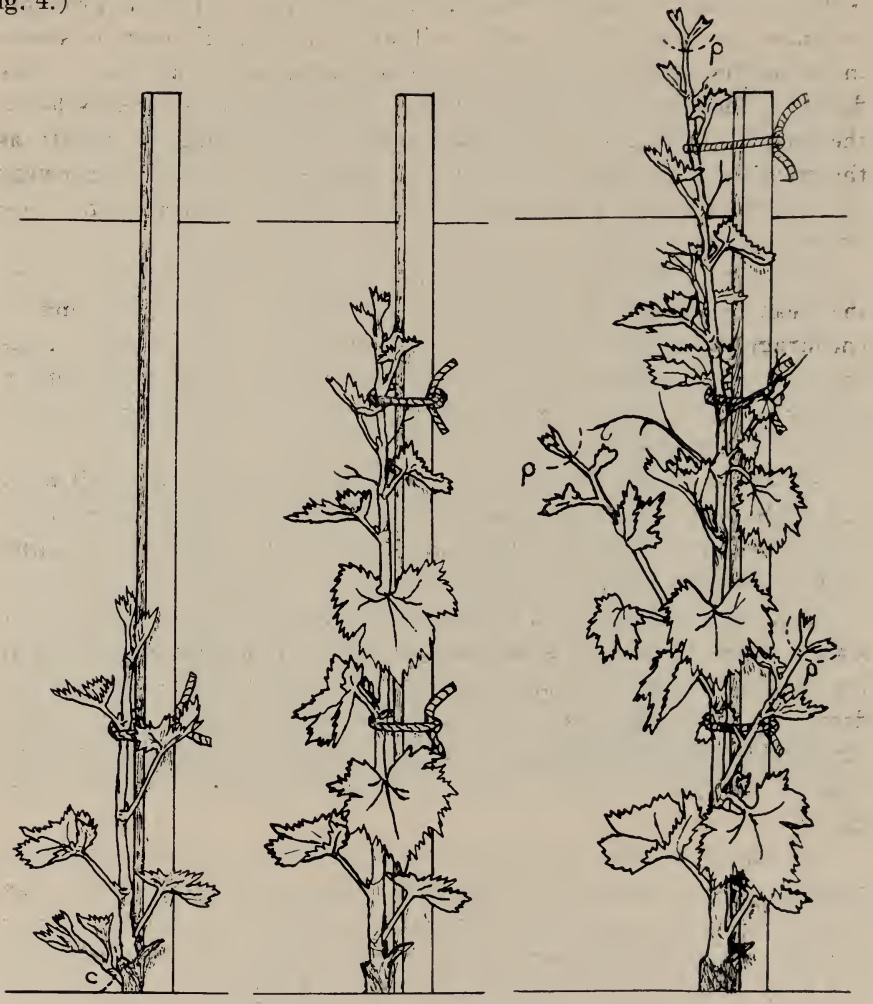


Fig. 5.—Tying the reserved shoot the second summer.

The reserved shoots will then grow rapidly and as soon as they are 6 to 12 inches long the vines should be disbudded the second time. This consists in rubbing off any new buds or shoots that have developed since the first disbudding. At this time, any vines which had not started before are disbudded for the first time. Also any shoots which have grown over eight inches are tied loosely to the stake with a piece of sacking twine or other soft string.

Later, as soon as the shoots have grown 12 or 15 inches more they are tied again nearer the top of the stake. With vines grown to high stakes three or more tyings are usually necessary. (See fig. 5.)

Only buds and shoots on the old part of the vine should be removed. *Nothing* should be taken from the reserved shoot which is growing. Secondary side shoots (*laterals*) will start on vigorous reserved shoots in the angles (*axils*) where the leaves are attached to the shoot. (See fig. 5.) These should not be removed. If any of these laterals below the middle of the main shoot show signs of developing as rapidly as the main shoot they should be *pinched,* that is, an inch of the growing tip should be pinched off when they are 12 to 15 inches long. (See fig. 5-p.)

When the main shoot has grown a few inches above the point where the head is desired it also should be pinched. This will tend to encourage the growth of laterals. All laterals on the upper half of the shoot should be allowed to grow without pinching unless they seem in danger of being broken by the wind, in which case they are pinched like the lower laterals.

4. *Second winter pruning.*—Soon after the leaves have fallen, at end of the second growing season, the vines should receive their second winter pruning. In frosty locations it is better to defer the pruning until a few days before the buds start in the spring.

Each vine will consist of a single straight cane tied vertically to the stake. If well grown, this cane should be cut off as near as possible at the level at which the head is desired. The cut is made through the first bud above the highest which it is desired to have grow. This cut is made in such a way as to destroy the bud but to leave the enlargement of the joint (*node*). This is to facilitate secure tying. (See fig. 6.)

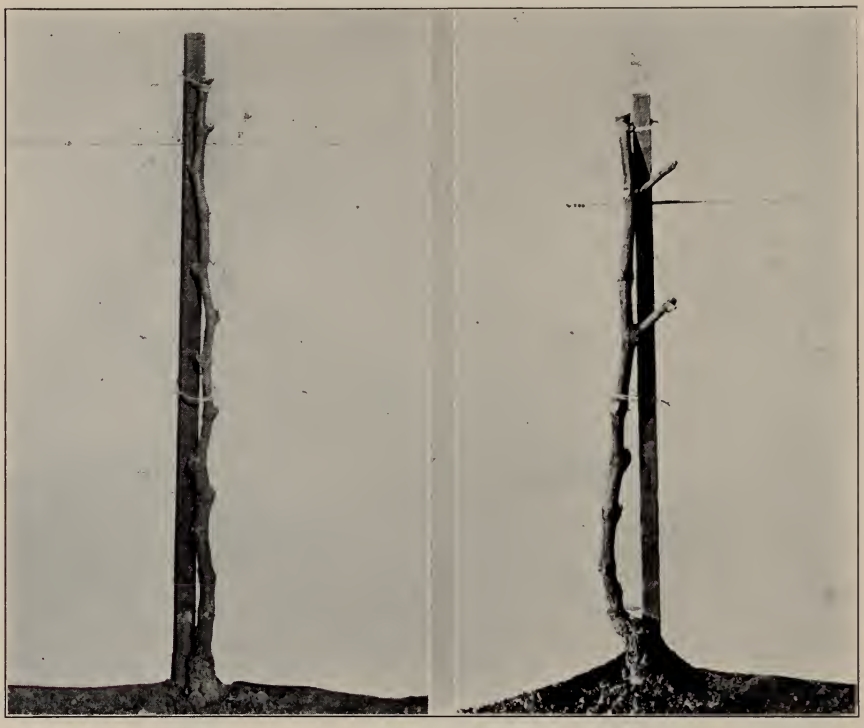
All small laterals and all laterals below the middle should be removed. On exceptionally large vines, laterals over three-tenths of an inch thick on the upper half of the cane should be cut back to one or two buds, according to their strength. These will act as fruiting spurs and help to develop the head rapidly. (See fig. 6*b*.)

Vines on which the cane is less than three-tenths of an inch thick at the desired height of the head should be cut back to two buds as at the first winter pruning. (See fig. 3.)

Before the buds swell in the spring, the pruned canes should be tied securely to the stake. A single or double half hitch is made around the cane just above the top bud and the string tied around the stake as tight as possible and with a firm square knot. (See fig. 6.) A loose tie is then placed around stake and cane about the middle. This tie

should not pass around the cane between the cane and the stake, or the vine will be girdled. If two fingers can be inserted between the cane and the string this danger is avoided.

Soon after the pruned vines are tied up and before the buds start, suckers and surface roots should be removed thoroughly and carefully as was done the previous year.



a *b*

Fig. 6.—Second winter pruning. *a*. Average vine. *b*. Extra vigorous vine.

5. *Third summer treatment.*—During the second summer, a cane has been produced which will develop into the permanent trunk. During the third summer a small or medium crop will be produced and the development of the head commenced.

The complete formation of the head will require at least three seasons except under the unusually intense growing conditions already referred to. An attempt to form the head too rapidly will result in loss of crop and the production of an ill-shaped vine.

During the summer, all the shoots which start on the lower third of the vine are removed as soon as possible after they start (see fig. 7). To allow them to grow six or more inches and then remove them stunts

the vine and delays its development. All shoots which start on the upper two-thirds should be allowed to grow without interference. Only in cases where they grow so large and with such rapidity that they are in danger of being broken by the wind should they be given

Fig. 7.—Third summer treatment—first disbudding.

any attention. In this case it is usually sufficient to pinch the tips when the shoots are about eighteen inches long. (See fig. 8.) This pinching may have to be repeated.

6. *Later prunings and treatments. Formation of the head.*—At the end of the third growing season, after the leaves have fallen, an

average good vine will consist of a well developed trunk from one to two inches thick, bearing on its upper two-thirds from four to eight good, well matured, healthy canes.

Fig. 8.—Third summer treatment. Second disbudding and pinching.

Enough of these canes should be reserved and cut back to spurs to bear the crop that the vine is judged capable of bearing without injury to its vigor and the proper maturing of the grapes. This will usually be from three to six according to the vigor of the vine, and each spur should be cut back to two, three or four buds according to its size.

These spurs should be as near the top of the vine as is possible. (See fig. 9*a*.)

During the summer no pruning will be needed except the removal, as soon after they start as is practicable, of all shoots that start below the bottom spur and of all suckers that come from below ground. A moderate pinching of vigorous shoots when they are 18 to 20 inches long may be necessary in windy situations.

a *b*

Fig. 9.—Formation of the head. *a*. Third winter pruning. *b*. Fourth winter pruning.

At the end of the fourth growing season each of the spurs of the last winter pruning should have produced one, two or more canes sufficiently vigorous to use for spurs. Commencing at the top of the vine, spurs of one, two or three buds should be left as evenly and symmetrically arranged as possible until sufficient buds are obtained to give the crop that the vine is capable of bearing. All growth below should then be removed. This will usually leave all the spurs on the upper third of the vine. (See fig. 9*b*.)

The summer treatment during the fifth growing season is identical with that of the fourth. No topping should be done, nor even any pinching, unless it is absolutely necessary to prevent serious wind damage.

The fifth winter pruning is a continuation of the method of the fourth. Spurs should be chosen at the top of the vine in such a way as to give the head and arms as nearly as possible the open vase form and in sufficient number to give the amount of crop suited to the size and vigor of the vine.

The vine now should be in full bearing and the head formed.

The pruning in later years depends on the same principles. The number of buds left should be in proportion to the vigor of the vine and they should be distributed on the spurs in proportion to the vigor of the latter. The distribution of the spurs should be such as to maintain or improve the shape of the head.

After a few years the arms will tend to become too long. This will render them liable to be injured by the implements of cultivation and make them weak because of the numerous small wounds that have been left in the annual winter pruning.

When this stage is reached it will be necessary from time to time to shorten the longer arms. This is done by leaving a replacing spur on the arm between its extremity and the head of the vine. The following year the arm is cut back to this spur from which a new arm is developed. It is best to start this replacing spur one or two years before it becomes necessary to shorten the arm.

This can be done only if water sprouts are allowed to grow on the arms during the summer. It is nearly always a mistake to remove these water sprouts until the winter pruning. They feed and invigorate the vine and enable it to bear more crop. On ill-shaped vines they may grow through the bunches and make harvesting difficult without injury to the fruit. This can be avoided, however, by disentangling the bunches and water sprouts early in the season when the grapes are about half grown. This is less expensive and more effective than disentangling them while harvesting.

CANE PRUNING

Head pruning as described gives good results only with varieties which are fruitful on the lowest two or three buds of the cane. For other varieties pruning back to spurs of two or three buds results in small crops or none at all, especially with a low or medium trunk.

In these cases it is necessary to leave *fruit-canes,* which are pieces of well-ripened canes usually from 2 to 4 feet long. The necessity of

supporting these canes to keep the fruit off the ground and of supplying new fruit canes from the head each year requires trellising and several other changes in the method of training.

The Trunk.—The form and development of the trunk are exactly the same as for head pruning.

The Head.—The only difference in the head is that it should be fan-shaped, that is extending in a plane in the direction of the trellis and not in all directions as in head pruning. This is necessary for convenience and economy of tillage which can take place in only one direction.

Fig. 10.—Mature cane pruned vine.

The Arms.—As a fruit-cane bears much more fruit than a fruit spur, fewer are needed and therefore fewer arms are necessary to produce these canes. Two arms on each side of the head are all that are needed by a vine in full bearing. (See fig. 10.) Great care should be taken to keep these arms in the line of the trellis and not jutting out into the spaces between the rows, where they would interfere with cultivation, make much hand hoeing necessary to keep weeds down, and be in danger of damage from implements.

The rules regarding the management of these arms are the same otherwise as for the arms of head-pruned vines.

The Fruit-Canes.—In head pruning, the spurs have two functions—the production of fruit and the production of canes for the following year.

In cane pruning, these functions are separated. The fruit-cane bears the fruit and a renewal spur is left to produce canes for the following year. This *renewal spur* is a spur, normally of two buds,

one of which is expected to produce a cane which can be cut back the next year to 2 to 4 feet for a new fruit-cane and the other to two buds for a new renewal spur.

Each year the fruit-cane which has borne is cut off and replaced by a new fruit-cane from the renewal spur. In cases where the renewal spur fails to give suitable canes, canes may be utilized from near the base of the fruit-cane of the previous year. This should be done as seldom as possible, because it tends to cause the arms to elongate very rapidly. Where it is necessary to leave a renewal spur pointing at right angles to the line of the row, it should be shortened to one bud. If the vine is vigorous, base buds will grow and such a spur will supply the two canes needed.

In order to prevent the arms elongating too rapidly, it is necessary whenever possible, to have the renewal spur nearer the head of the vine than the fruit-cane. Also, replacing spurs, to shorten long arms, must be used occasionally as in head pruning.

The number of fruit-canes to leave will depend on the size and vigor of the vine. An average vine, the first year of bearing, will need only one, with two or three renewal spurs. (See fig. 11.) The next year it will need two or three, with four or five renewal spurs. (See fig. 12.) At the third crop the vine should be in full bearing and will need four fruit-canes with four or five renewal spurs if it has made the amount of growth that it should. (See fig. 10.)

It is sometimes difficult or impossible to find well-placed canes for the required number of renewal spurs. This will not usually lead to any serious defect with a vigorous vine, as canes will be produced from dormant buds on the arms or head. If the vine is weak, few or no fruit-canes should be left, and this will promote a growth of suitably placed shoots from dormant buds.

The Trellis.—For the support of the canes and their crop, a trellis is needed, usually of two wires stretched along each row from posts at the side of each block.

The lower wire is at the height of the head of the vine and the upper 13″ to 15″ higher. The fruit-canes are tied horizontally to the lower wire. The upper wire is simply to support the shoots from the fruit-canes, to protect them from wind damage, and to keep the fruit off the ground. This trellis should be put up at the end of the first growing season. (For full directions concerning trellising see Circular 252.)

As the fruit-canes and their crop will be very heavy, they should be tied in such a way that most of the weight will fall on the wire and not on the string by which they are tied. This is accomplished by giving the cane about one and a half turns around the wire and tying

firmly at the end. (Figs. 11 and 12.) No other tie is needed in most cases. The cane should not be twisted several times around the wire, as this will make it difficult to remove at the following winter pruning.

Fig. 11.—Cane-pruned vine—third winter pruning.

Fig. 12.—Cane-pruned vine—fourth winter pruning.

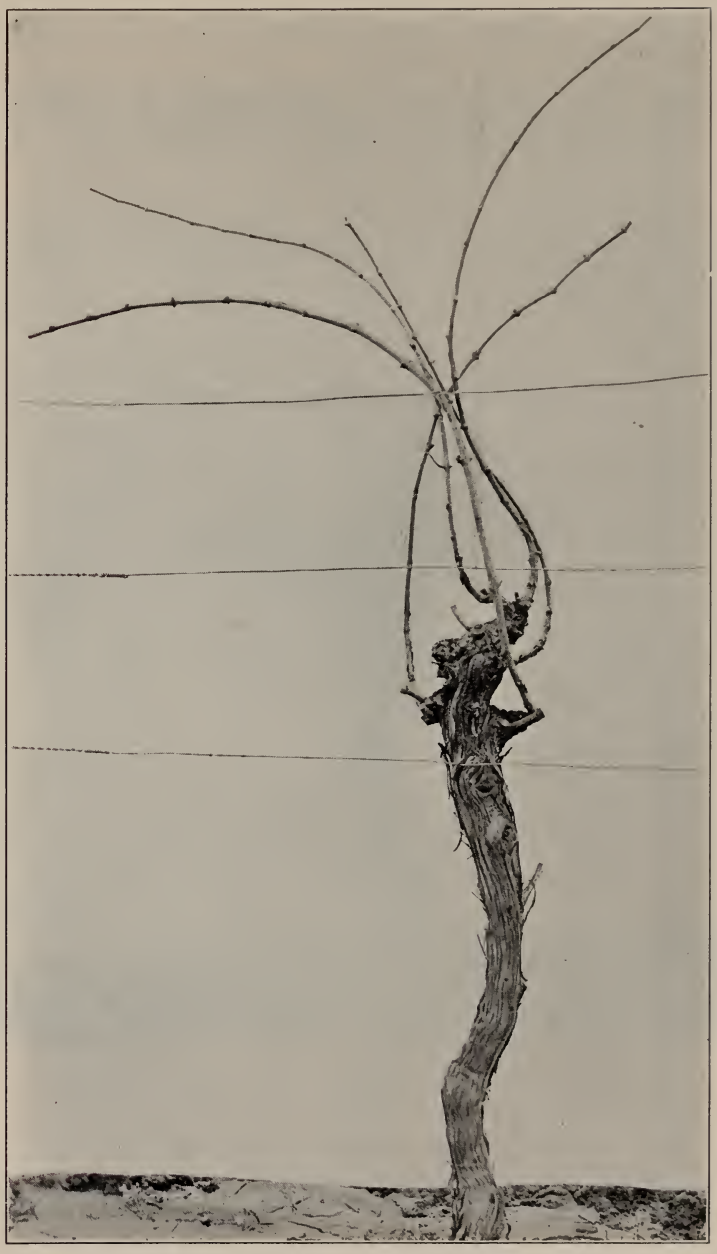


Fig. 13.—High-headed cane-pruned vine tied up for frost protection.

Another Method.—A modification of this method has been used successfully for vigorous vines growing in very fertile soil and is especially useful in frosty locations.

A third wire is placed about 12 inches above the second, and the head of the vine is brought up nearly to the second wire. (Figs. 13 and 14.)

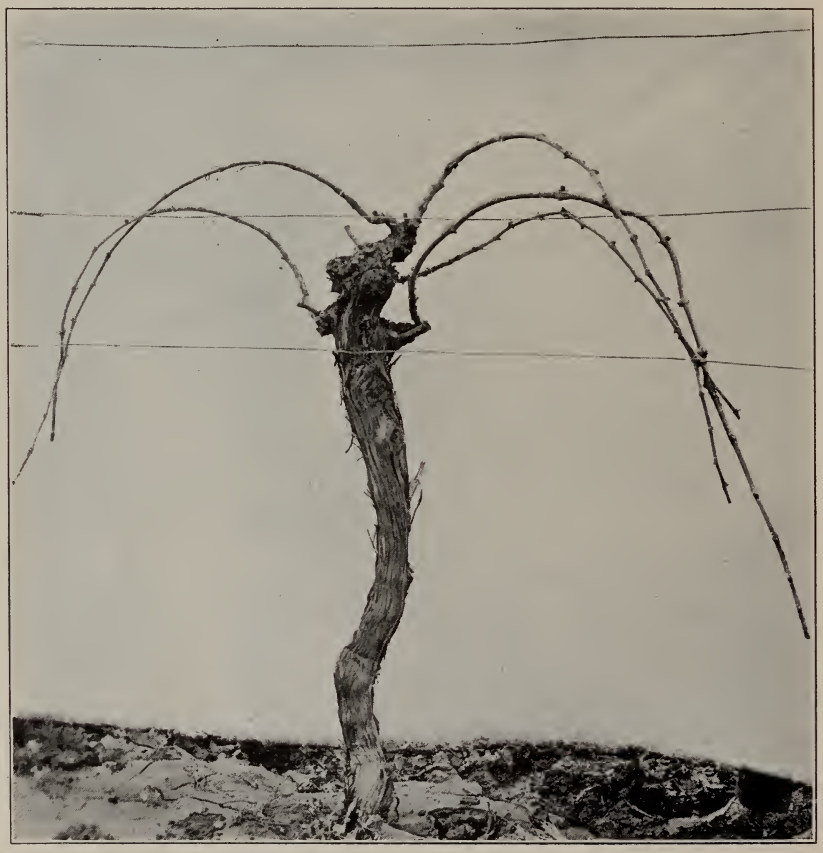


Fig. 14.—Vine of fig. 13 after canes are tied down.

The pruning is exactly the same as for the first method except that, being applied only to very vigorous vines, somewhat longer canes and occasionally an extra one may be needed.

After pruning, the fruit-canes are not tied or are tied only temporarily to the top wire as nearly vertically as possible. This places them in a position where they are safer from frost. (Fig. 13.) After

most danger of frost is over, the canes are put in their final position. They are bent over the middle wire and tied down to the bottom wire (fig. 14).

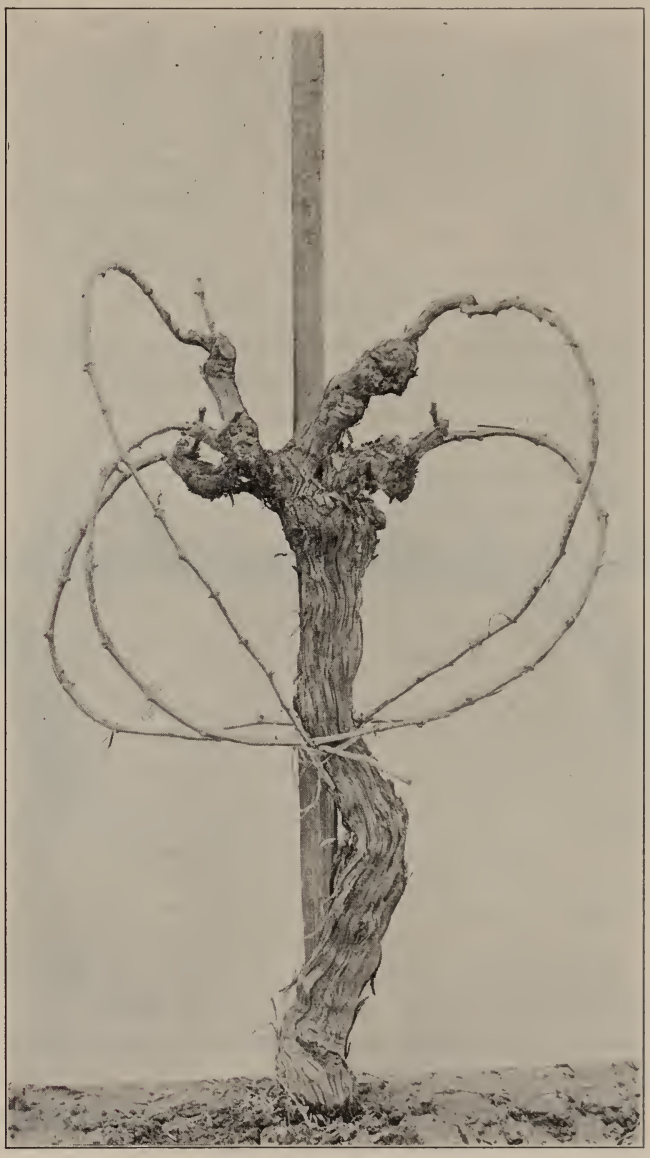


Fig. 15.—Cane-pruned vine without trellis.

Vines pruned in this way can be handled without a trellis. In this case the canes are simply bent downward and tied to the lower part of the trunk (see fig. 15). When this is done, renewal spurs are less

needed as shoots for the fruit canes of the following year are forced from near the base of the fruit canes of the current year behind the bend.

An advantage of this method is that it permits of cross cultivation. Disadvantages are that the fruit is massed together, which makes harvesting and the control of mildew more difficult, and the new shoots from the head of the vine on which the crop of the following year depends are liable to be broken by the wind. By the use of a 7-foot stake and tying the growing shoots to the 18 inches of stake above the head, this breaking can be prevented to some extent. (See fig. 15.)

CORDON PRUNING

Some varieties do not give full crops with head pruning and their fruit is of inferior size and quality with cane pruning. Both of these defects can often be overcome by cordon pruning.

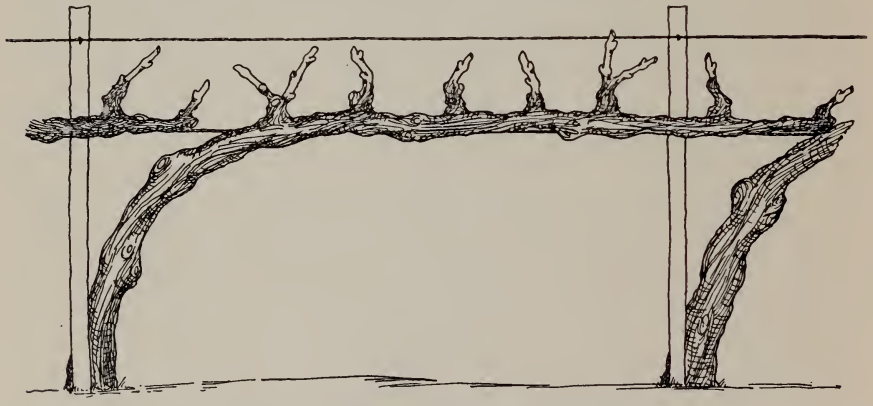


Fig. 16.—Completed unilateral cordon.

The Trunk.—The characteristic of *cordon pruning* is that the vine is given a much longer trunk than in the other systems. Instead of being 2 or 3 or at most 4 feet high, it is extended to 8, 10 or more feet; and in the unilateral form instead of being vertical, it rises in a gentle curve (a quarter circle) to a height of 30 to 40 inches and then extends horizontally to the next vine (fig. 16).

This extension of the trunk has the effect of making the buds on the lower part of the canes fruitful. Some varieties which require fruit-canes with head pruning bear well on spurs when pruned by the cordon system.

The length of the trunk distributes the crop over a larger space and tends to keep the bunches separate from each other and from the

shoots. The bunches are thus more perfect and can be more easily harvested without injury. The horizontal position of the trunk places all the bunches at about the same distance from the ground and makes possible more nearly equal uniformity in quality, color, and time of ripening.

The cordon system is particularly suited to vigorous varieties of table grapes which produce large berries and large bunches. It requires good soil and abundant water. Weak growing vines fail with this system.

Head, Arms, and Spurs.—The vine has no head and the arms are distributed along the upper side of the horizontal part of the trunk at intervals of 10 to 12 inches. It is very important that the arms should all be on the upper side; otherwise the fruit will be too low and finally lie on the ground, and the trunk will be without shade and will be injured by the hot sun. To insure this requires particular care during the first three or four years.

The arms, as with the other systems, gradually elongate and after several years must be replaced. As most varieties should be pruned to short spurs with this system, the arms elongate slowly. The management of the spurs is similar to that used in head pruning, except that care should be taken to have them as vertical as possible.

Development of a Unilateral Cordon

The treatment during the first year is exactly the same as for the other systems. As a longer and more vigorous cane is needed for the formation of the trunk, it is more often necessary to cut the vine back to the ground after the second as well as after the first growing season and to take three years to form the cane for the trunk.

1. *Formation of the Trunk-Cane.*—At the end of the first, and if necessary the second, season the vine is reduced to one cane and this cane cut back to two good buds (see fig. 3).

A trellis is then put up similar to that recommended for cane pruning with two wires. (See Circular 252.) During the following summer, the treatment is the same as that described for head pruning up to the time the vine reaches the stage shown in fig. 5*c*. After this stage the strong laterals are pinched as shown in fig. 5*c*, but the end of the shoot is allowed to grow until it is about two feet above the top wire (fig. 17*a*.)

At this stage all the ties are removed except the lowest at 8 to 10 inches from the ground. The shoot is then bent over and tied loosely to the bottom wire. (Fig. 17*b*.)

This shoot is then allowed to grow and is tied again once or twice to the wire as it lengthens. No tie should be placed nearer than about 15 inches from the growing tip or the shoot may be stunted. If the shoot grows long enough, it is pinched after it has passed the adjoining wire about a couple of feet.

a *b*

Fig. 17.—Unilateral cordon. Placing the growing shoot on the wire.

2. *Pruning the Trunk-Cane* (second or third winter).—At the end of the season, after the leaves have fallen, the trunk-cane should be cut back to a place where it is at *least half an inch thick.* If it has grown sufficiently, it may be allowed to extend to the top of the bend of the adjoining vine. If it has not made a cane sufficiently large to reach at least 12 inches along the wire beyond the bend, it must be cut back to within 6 to 8 inches of the ground and a more vigorous cane grown the next year. Many failures are due to using small canes.

The cane is then straightened by turning it around the wire from once to twice according to its length. It should not be turned around the wire more than is necessary to make it straight, and in any case not more than twice and this only with canes of full length. If twisted too many times, it will be cut by the wire as it grows and will be injured or broken the next year when it becomes necessary to untwist it. (Fig. 18.)

The end of the cane should be tied firmly to the wire around the stub projecting beyond the end bud. If there then remains any parts of the cane which are not close to the wire, these should be straightened

Fig. 18.—Unilateral cordon. Trunk-cane of nearly full length.

by other ties. These latter ties should be loose enough to allow for growth of the cane, which may reach 1 or 1½ inches in diameter during the summer.

3. *First Summer Treatment on the Wire.*—During this season the first crop will be borne and the vine will produce canes from which to start its arms.

Two serious dangers are to be avoided. One is the production of too much crop. This will result in grapes of poor quality and of no value and a weakening of the vine which will prevent it from producing the canes necessary for spurs the next year. The other is the development of canes on the lower side of the trunk-cane instead of on the upper side.

While the buds are starting in the spring, the vineyard should be gone over several times and every shoot starting on the under side of the cane rubbed off. This will remove half the shoots and leave the other half, spaced 6 to 10 inches apart on the upper side. This disbudding should be done as soon as possible, and no shoot which is to

be removed should be allowed to grow more than about an inch. At the same time all shoots starting on or below the bend should be pinched back, leaving three or four leaves on each to shade the trunk.

As the shoots on the upper side grow at uneven rates, some of them will soon be much longer than the others. These long shoots are usually near the bend or at the end. They should be pinched as soon as this can be done without injurying the blossom bunch, which is usually at the third or fourth joint. This pinching will check the growth and allow the weaker shoots to catch up with the others. (Fig. 19.)

Fig. 19.—Unilateral cordon. First year on the wire. Shoots ready for tying to the upper wire. Longest shoots ready for pinching.

On vines which do not extend the full length, a shoot should be allowed to grow from near the end to complete the trunk and tied when long enough to the wire. A shoot from the under side of the cane is best for this purpose.

As soon as the shoots are sufficiently long, one, two, or three of them should be tied to the upper wire. If this is not done, all the shoots which start on the upper side of the trunk-cane will turn over and their weight, with that of the fruit they bear, will be so great as to turn the trunk-cane completely over and leave the upper side bare and the new canes all pointing toward the ground. If this happens the vine can never be made into a successful cordon.

This tying of supporting shoots is necessary only the first year because the second year the trunk is sufficiently thick and rigid to prevent turning. In very windy locations, however, it is useful to tie the

first strong shoots that grow along the trunk even of older vines to prevent breakage by the wind.

4. *Pruning the completed cordons.*—The first winter pruning after the trunk-cane has been completed on the wire consists in leaving spurs along the upper side of the horizontal trunk. These spurs should be spaced about 8 to 14 inches apart as evenly as possible. In case there

Fig. 20.—Unilateral cordon. Summer treatment. Second summer on the wire.

is no cane on the upper side where a spur is needed a cane from the lower side must be taken. By cutting this back to one bud a strong shoot will be obtained which, when it has grown long enough can be tied to the upper wire and will provide a vertical shoot for the next year.

The length of the spurs will depend on the vigor of the vine and of the cane. It will vary from one to three buds. At each winter

pruning thereafter a spur is formed from a cane that grew from the spur of the previous year and, in time, short vertical arms will be formed along the top of the trunk.

These arms should be allowed to lengthen gradually until they reach the height considered best, usually about 10 to 12 inches. After this they should be shortened by means of replacing spurs as with head pruning.

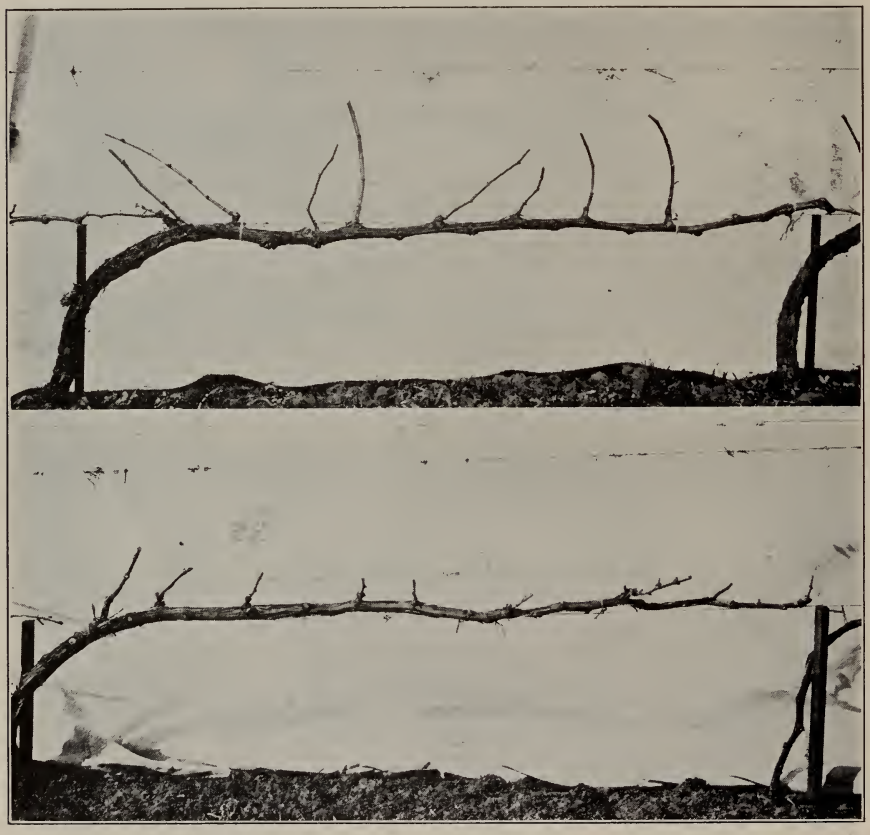


Fig. 21.—Unilateral cordon. Winter pruning—third year on wire, long or double pruning.

The completed cordons will need little or no summer pruning, as is the case also with well-formed vines of any other system. For a year or two shoots will form on the bend of the trunk and the under side. These should be removed early. (See fig. 20.)

5. *Long Pruning.*—While the cordon system nearly always makes it possible to obtain maximum crops with short or spur pruning there may be some cases, as the Ohanez growing in very rich soil, where a

modification in the direction of cane pruning might be advisable. In such cases a method of pruning similar to that illustrated by fig. 21 can be adopted.

Instead of spurs of one to three buds, canes of five to eight buds would be left. It would usually be necessary to tie these canes to the upper wire.

6. *Frost Protection.*—The vine shown in the upper part of fig. 21 has been pruned long temporarily as a measure for frost protection. If the vine is pruned in this way during the winter the buds at the end of the short canes will start at the usual time in spring. The canes

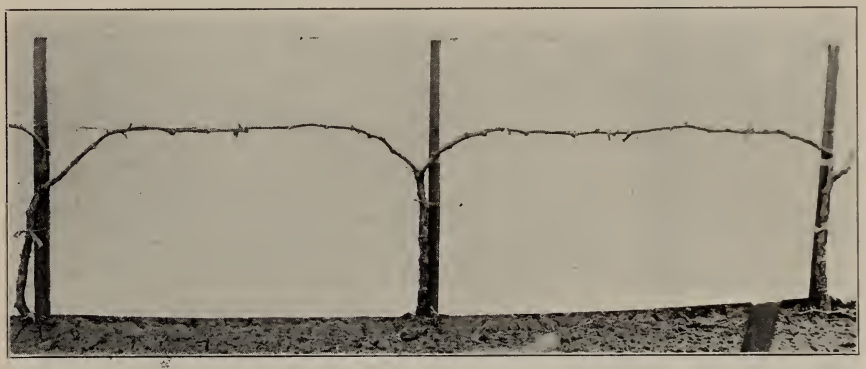


Fig. 22.—First year on the wire. Bilateral cordon.

are then pruned back to spurs the buds of which are dormant and will not start for a week or ten days after the buds of similar vines pruned short earlier in the usual way.

The vine shown in the lower part of the figure shows how this cutting back is done. This is a useful means of protection in frosty locations.

7. *Bilateral Cordon.*—The bilateral cordon consists of a vertical trunk rising to a height of 24 to 30 inches and there dividing into two branches which are conducted horizontally on a wire at 36 to 40 inches from the ground. The arms go in opposite directions and reach half way to the adjoining vine (figs. 22 and 23).

This method has most of the advantages of the unilateral and can be used where the latter is impracticable. A good unilateral cordon can be made only if it is started at the latest the second year. A fairly good bilateral can be formed from a head or cane-pruned vine of good form after the vine is several years old. It also requires somewhat

less skill and if found unsuitable can easily be changed to the head or cane system by simply cutting back the branches.

There is a tendency with this system for one branch to grow at the expense of the other but this can be controlled by pruning the spurs of the weaker arm shorter and thus limiting its crop until it recovers its vigor.

Fig. 23.—Bilateral cordon. First or second summer on the wire. Long shoots near the ends ready for pinching.

The curves of the two branches, going in opposite directions, result in a space of about two feet where there are no spurs, thus limiting the fruiting surface. If spurs are left on the curves they tend to appropriate the sap flow and weaken the arms. The difficulty can be overcome by allowing the first arm on the horizontal part of the branch to fork and fill up the unoccupied space.

In developing a bilateral cordon the treatment for the first three years is the same as for cane pruning except that no renewal spurs are left and only two canes, one on each side. These canes are not removed but left as permanent branches on the upper side of which short arms are developed as in unilateral cordons.

CHOICE OF A SYSTEM

Whatever system we adopt we must make our choice before we plant the vineyard if we are to obtain all the benefits of any system. The best number and arrangement of the vines, position of roads and avenues and method and direction of irrigation will vary according to the system of pruning adopted. (See Circular 253, "Vineyard Plans.")

In deciding upon a system we should consider its probable cost returns and practicability, as well as its suitability to the variety of vine, the soil and climate, and the use to be made of the fruit.

Cost.—The most economical in first cost of stakes or other supports, and in the work of pruning, tillage and harvesting is head pruning. Unless the extra cost is more than counterbalanced by extra returns from the other systems, head pruning should be adopted.

Returns.—Most varieties give fair to maximum crops with head pruning. With some varieties, however, the crops are small and with others the quality inferior with this system. For most wine grapes and for the raisin Muscat this system is perfectly satisfactory.

For certain table grapes, such as Malaga, Tokay and Black Prince head pruning with a high trunk is usual and generally satisfactory though it is probable that under suitable conditions of rich soil, abundant water supply and hot climate, better results in both quality and quantity of crop might be obtained by the cordon system. Other varieties of table grapes, such as Emperor, Cornichon and Ohanez usually give poor crops with head pruning and require some form of cordon or similar means of extending the trunk beyond the limits of head pruning. Cane pruning will increase the crops of these varieties but at the expense of quality.

For the seedless raisin grapes, Sultanina (Thompson), Sultana and Black Corinth, cane pruning is almost always used. These varieties bear very little with head pruning and they have not been thoroughly tested with the cordon method.

Practicability.—Head pruning is the most commonly understood and if improperly or unskillfully applied, the results are perhaps less disastrous than with the other systems. However, no system is profitable unless carried out properly and if the owner of a vineyard will take pains to understand any system and to carry it out properly there is very little more difficulty with one system than with another.

Cane pruning perhaps requires the most experience and cordon pruning the least. The unilateral cordon system, nothwithstanding the greater care and knowledge needed during the first three or four years, can be reduced to a set of practical rules to be followed by any intelligent man more easily than any of the others. But these rules must be known and adhered to.

Suitability to variety.—The general considerations which should influence our choice of a system for each variety have been discussed. The following list of our commoner varieties, with the systems of pruning to which they seem most adapted, must not be taken as absolute. Various conditions of soil, climate, and use of the fruit introduce modifying considerations.

SYSTEMS SUITABLE FOR THE COMMONER VARIETIES GROWN IN CALIFORNIA*

Head Pruning.†— Alicante Bouschet, Aramon, Black Morocco, Black Prince (cd?), Carignane, Burger, Charbono, Chasselas (=Gutedel), Feher Szagos, Grand noir, Grenache, Malaga (cd), Mataro, Mission (cd?), Mondeuse, Muscat, Palomino (=Napa Golden Chasselas) (cd), Petit Bouschet, Petite Sirah (Duriff) (cn), Rose of Peru (cd?), Tokay (cd?), Verdal (cd?), Zinfandel.

Cane Pruning.—Black Corinth (=Panariti, Zante), Cabernet, Colombar (=Sauvignon vert) (cd), Semillon, Sultana, Sultanina (=Thompson) Trousseau (h), Pierce (and nearly all other Eastern varieties such as Concord and Isabella.

Cordon Pruning.—Black Monukka, Cornichon, Dattier, Dizmar, Emperor, Ferrara, Gros Colman (=Fresno Beauty, Servian Blue) (h), Gros Guillaume (=Danugue) (h), Hunisa, Molinera (=Maraviglia di Malaga, Red Malaga (h), Ohanez (=Almeria), Olivette blanche, Prune de Cazoul, Rish Baba (=Humphrey's Lady Finger), Zabalkanski.

Supplementary Information.—Circulars 245, Pruning Systems; 248, Common Errors in Pruning; 252, Supports for Vines; 253, Vineyard Plans. For free copies apply to the College of Agriculture, Berkeley.

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* Only those varieties are included which are grown in sufficient quantities to appear in market quotations.

† Varieties which do well under other conditions are marked: (h) = head pruning; (cn) = cane pruning; (cd) = cordon pruning.

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